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## Factors Affecting the Results of Tricuspid Annuloplasty, Especially Left Heart Factors

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### Introduction

Tricuspid annuloplasty is the treatment of choice for functional tricuspid regurgitation in patients with mitral valve disease. While various types of tricuspid annuloplasty have been tried, the assessment of the efficacy of these techniques is still controversial because of the difficulties in the evaluation of tricuspid regurgitation. We recently developed a new radioisotope method of estimating the degree of tricuspid regurgitation<sup>6)</sup> and compared tricuspid valve function following three types of tricuspid annuloplasty; KAY-BOYD's, DEVEGA's and CARPENTIER's methods. Our study<sup>7)</sup> revealed that CARPENTIER's ring plasty was the most effective for all grades and types of regurgitation. However, the results of tricuspid annuloplasty are influenced by the quality of the left side repair as well as by the techniques of tricuspid annuloplasty per se<sup>4,5)</sup>.

In this report, we focus on the factors affecting the prognosis of tricuspid annuloplasty, especially on the influence of the left heart factors.

### Materials and methods

The severity of tricuspid regurgitation was estimated by a newly developed radioisotope method in a total of 32 operative survivors who underwent tricuspid annuloplasty combined with mitral valve surgery. The patients were divided into two groups on the basis of the results of this radioisotope examination. In group I (14 patients) the residual or recurrent tricuspid regurgitation was greater than 30% and in group II (18 patients) it was less than 30% (Fig. 1). Follow-up periods were  $60 \pm 43$  months in group I and  $34 \pm 33$  months in group II. Other characteristics of these groups are summarized in Table 1.

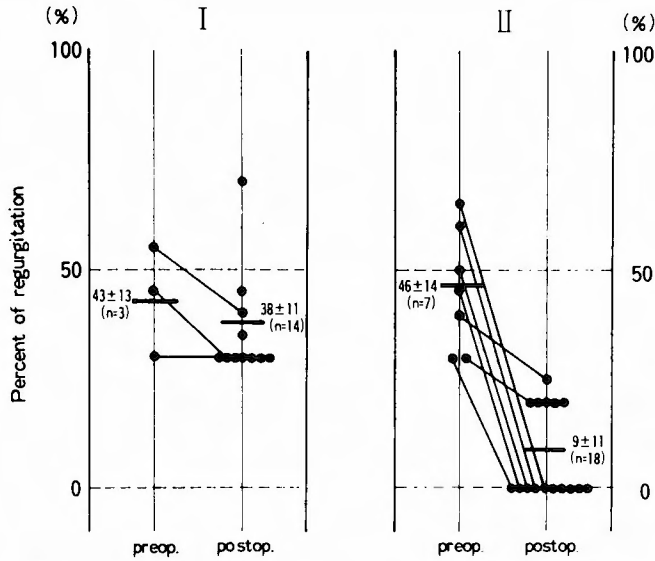
Our radioisotope method has been reported in detail elsewhere<sup>6)</sup>. In brief, after a rapid

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Key words: Functional tricuspid regurgitation, Tricuspid annuloplasty, Pulmonary artery wedge pressure, Pulmonary vascular resistance, Assesment of tricuspid regurgitation.

索引語: 機能的三尖弁逆流症, 三尖弁輪形成術, 肺動脈楔入圧, 肺血管抵抗, 三尖弁逆流の定量.

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**Fig. 1.** Estimation of tricuspid regurgitation by radioisotope method. Because of the recent advent of this method, preoperative examination was not done in some patients.

intravenous injection of <sup>99m</sup>Tc-macroaggregated human albumin, the time-activity curves of the right atrium and the right ventricle obtained with a scintillation camera were analyzed by an analog computer constructed according to a mathematical model in which the right atrium and the right ventricle were represented by a single mixing chamber and tricuspid regurgitation was expressed as a reverse flow from the right ventricle to the right atrium with a time delay equivalent to one cardiac cycle. More than 30% regurgitation by this method is clinically significant

**Table 1.** Characteristics of patients with (group I) and without (group II) significant tricuspid regurgitation.

Group	No of pts.	Age (mean±SD) Male/female	Duration of symptom (yrs)	Atrial fibrillation	Primary disease	Surgical method for primary disease	Type of tricuspid annuloplasty	Uncorrected associated lesion
I	14	39±12 4/10	16±9	12 (86%)	MS	7	MVR 7 OMC 5 MVR+AVR 2 Bex 1	Kay-Boyd 8 DeVega 5 A R 1
					MR	2		
					MSR	3		
					MSR+ASR	2		
II	18	44±11 2/16	13±8	15 (83%)	MS	8	MVR 11 OMC 5 MVR+AVR 1 MAP + ASD closure 1	Kay-Boyd 5 DeVega 2 Carpentier 11
					MR	3		
					MSR	5		
					MR+ASR	1		
					MR+ASD	1		
					MAP + ASD closure	1		

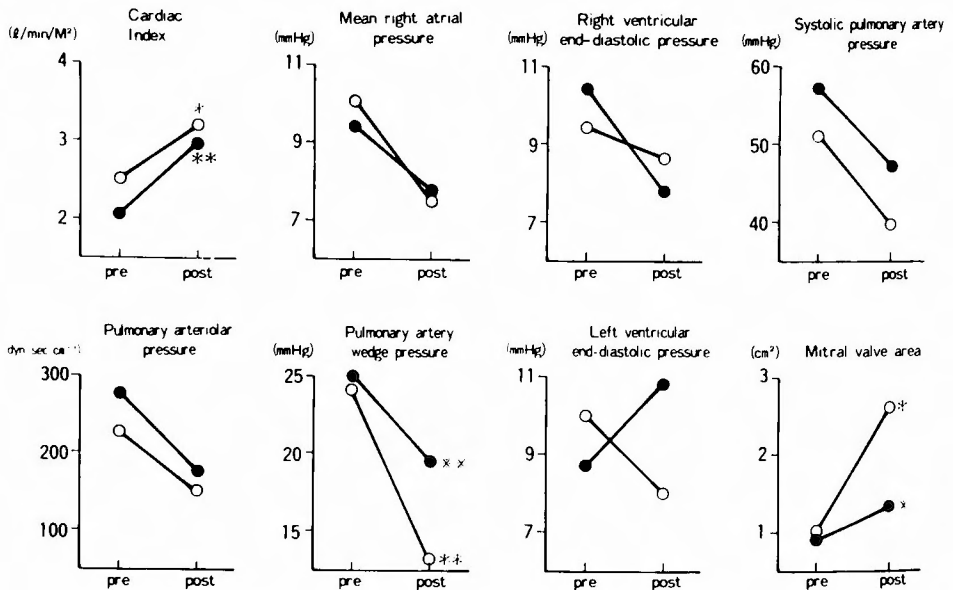
ASD : atrial septal defect, AS (R) : aortic stenosis(regurgitation), A (M) VR : aortic(mitral) valve replacement, MS (R) : mitral stenosis(regurgitation), MAP : mitral annuloplasty  
OMC : open mitral commissurotomy.

and of such severity that at operation regurgitation can always be diagnosed by inspection or palpation of the tricuspid valve. Radioisotope examination was done pre- and postoperatively in the recent cases, but only in the late postoperative period in the earlier cases, since it is a new method. Cardiac catheterization was performed before and within one year after surgery. Echocardiography and radiocardiography<sup>8)</sup> were repeated in the course of follow-up of the patients. These data were compared between the two groups.

### Results

There were three late deaths, one after mitral valve replacement and two after aortic and mitral valve replacements. The deaths were related to 1) right heart failure due to dysfunction of the tricuspid valve repaired by KAV-BOYD's annuloplasty, 2) myocardial infarction and 3) left ventricular aneurysm following mitral valve replacement.

Surgery resulted in hemodynamic improvement of most parameters, but this was significant only in the cardiac index in both groups, in the pulmonary artery wedge pressure in group II and mitral valve area in those patients in group II who underwent mitral commissurotomy, because of wide scattering of the values (Fig. 2). Comparison between the two groups revealed that a significantly higher pulmonary artery wedge pressure and smaller mitral valve area remained in group I ( $p < 0.02$  &  $p < 0.05$ , respectively). Although there was no specific correlation between the degree of tricuspid regurgitation and pulmonary artery wedge pressure, CARPENTIER'S



\* =  $P < 0.05$ , \*\* =  $P < 0.005$ , when compared with preoperative values

† =  $P < 0.05$ , †† =  $P < 0.02$ , when compared with group II

● Group I  
○ Group II

Fig. 2. Pre- and postoperative hemodynamic data in patients who had cardiac catheterization both pre- and postoperatively. Mitral valve areas were compared only in patients with mitral commissurotomy.

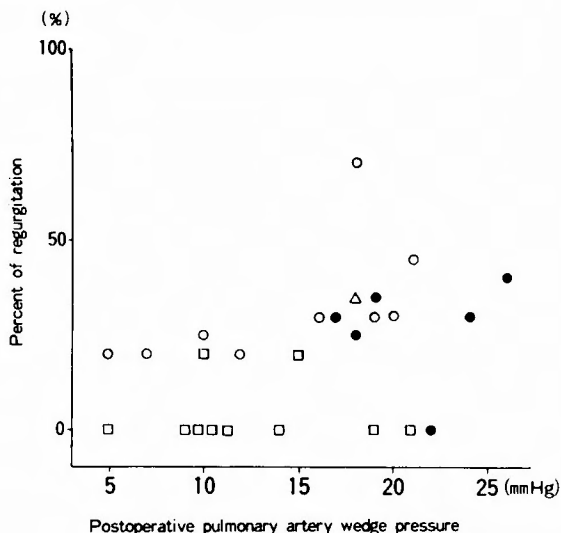


Fig. 3. Residual or recurrent regurgitation in relation to postoperative pulmonary artery wedge pressure.

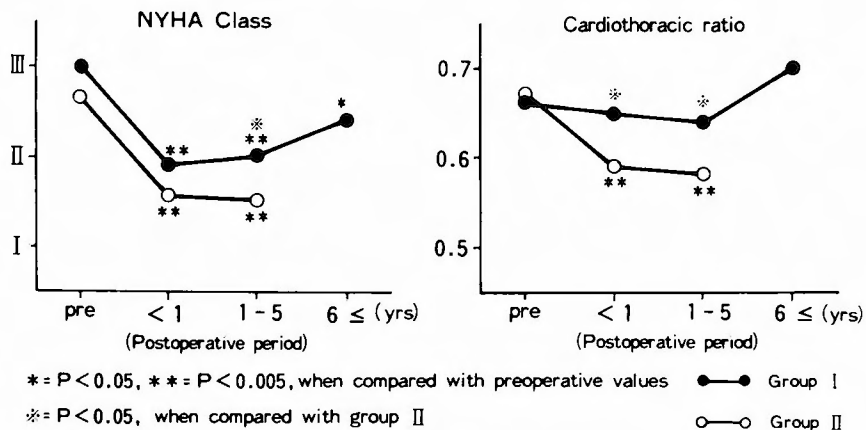


Fig. 4. Follow-up of postoperative functional status and cardiothoracic ratio.

method appeared to lead to better results even in the patients who had persistent high pulmonary artery wedge pressure of more than 15 mmHg postoperatively (Fig. 3).

In the follow-up study of the patients, persistent cardiomegaly and poor functional recovery were apparent in group I (Fig. 4). The hemodynamic state as determined by radiocardiography (Fig. 5) and echocardiography (Fig. 6) revealed that all parameters appeared better in group II, but not significantly so except for left heart volume, which remained high in group I pre- and postoperatively. A tendency to late deterioration was seen in group I about five years after surgery.

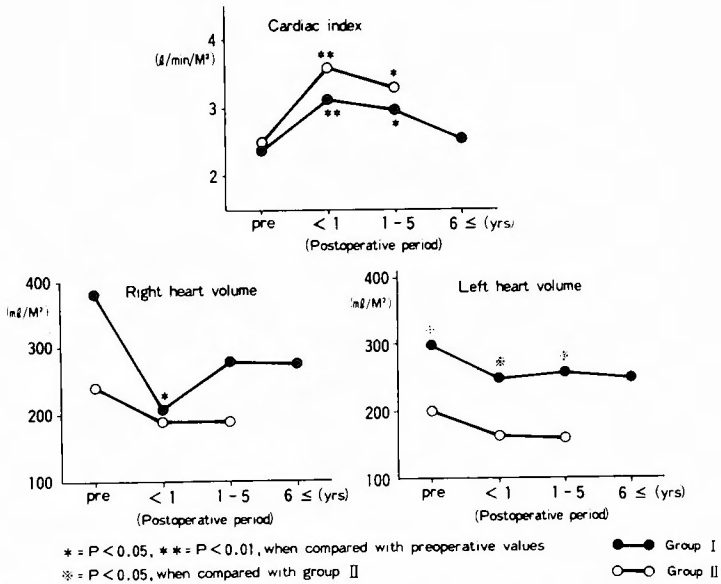


Fig. 5. Follow-up of cardiac index and right and left heart volumes by radiocardiography.

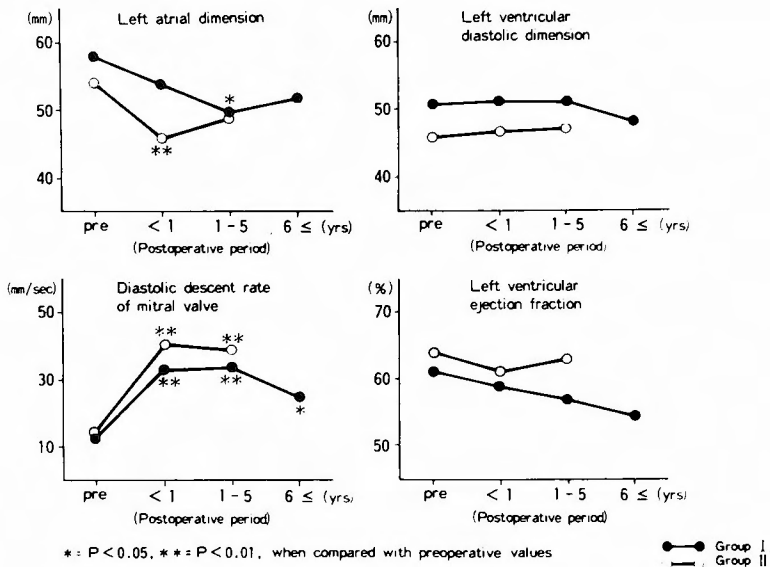


Fig. 6. Follow-up by echocardiography.

### Discussion

Factors which influence the results of tricuspid operation are present in both the right and left sides of the heart. The quality of the right side repair and method of tricuspid annuloplasty were discussed in a previous report<sup>7</sup>. In this study, we examined the left-side status in relation to residual or recurrent tricuspid regurgitation as evaluated by our own quantitative method. It is generally considered that myocardial failure, residual mitral stenosis, persistent high pulmo-

nary vascular resistance and uncorrected aortic valve disease are the left heart factors which might be closely connected with recurrent or residual tricuspid regurgitation. This study confirmed that persistent high pulmonary artery wedge pressure and residual mitral stenosis were the significant determinants of the poor results of tricuspid annuloplasty. However, pulmonary artery pressure and pulmonary vascular resistance decreased after surgery with no significant differences between patients with and without significant tricuspid regurgitation. The relationship between functional tricuspid regurgitation and persistent pulmonary vascular resistance is well-known<sup>2,9)</sup>, but SIMON et al.<sup>11)</sup> and FRATER<sup>3)</sup> observed that some patients with low pulmonary vascular resistance continued to have functional tricuspid regurgitation after surgery. According to them, the function of the periannular myocardium of the right ventricle, which is responsible for the reduced annular shortening of the tricuspid valve, appears to play a role in the pathogenesis of tricuspid regurgitation. STARR<sup>13)</sup> stated that right ventricular-valvular disproportion was a more important factor in the development of tricuspid regurgitation than annular dilatation of the tricuspid valve. The relatively large left heart volume and low left ventricular ejection fraction demonstrated by radiocardiography or echocardiography in our patients with tricuspid regurgitation might indicate poor myocardial function in this group.

Unfortunately, left heart results were sometimes unpredictable from the pre- or intraoperative evaluation, and pulmonary vascular resistance was not absolutely dependent on the adequate correction of the left heart lesions. Furthermore, uncorrected tricuspid regurgitation frequently led to high mortality and poor functional result, even if the correction of the left-side lesions appeared to be complete. It is sometimes quite difficult to distinguish between reversible and irreversible functional tricuspid regurgitation at the operating table<sup>12)</sup>. For these reason, many surgeons strongly advocate correction of tricuspid regurgitation, as do we. At present we recommend CARPENTIER's ring plasty<sup>1)</sup> for all patients who have had a significant tricuspid regurgitation at any time preoperatively. This method permits a selective plication of the annulus and the remodeling and fixation of the tricuspid annulus by a prosthetic ring of suitable shape and size. These seem to be the most important factors to eliminate regurgitation and to prevent recurrent dilatation of the annulus. In our experience, even in patients with persistent high pulmonary artery wedge pressure postoperatively CARPENTIER's method has yielded satisfactory results.

### Summary

It is generally considered that the quality of the left heart lesions is closely connected with the prognosis of functional tricuspid regurgitation. We examined left heart factors in relation to residual or recurrent tricuspid regurgitation, evaluated quantitatively by the radioisotope method developed by us. A total of 32 operative survivors who underwent tricuspid annuloplasty combined with mitral valve surgery were divided into two groups; one with a significant tricuspid regurgitation of more than 30%, and one with less than 30% regurgitation. Various parameters determined by cardiac catheterization, radiocardiography and echocardiography were compared between the two groups. Persistent high pulmonary artery wedge pressure and residual mitral

stenosis were the significant determinants of the poor results of tricuspid annuloplasty. The influence of pulmonary vascular resistance was not apparent. Since it is difficult to predict the reversibility of functional tricuspid regurgitation at the operating table, tricuspid repair should be actively done in all patients who have had a significant tricuspid regurgitation at any time preoperatively.

#### Acknowledgement

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## 和文抄録

三尖弁輪形成術の予後に影響する因子  
とくに左心因子について

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僧帽弁弁膜症に合併した三尖弁逆流症 (TR) に対する三尖弁輪形成術 (TAP) の予後の評価には、その術式の選択の問題以外に左心因子の関与も無視出来ない。我々の経験した TAP 症例のうち手術死を除く32症例を対称に、これらを我々の開発した TR 定量法を用いて、30%以上の有意の逆流が残存している群と、それ以下の群とに分け、心臓カテーテル、心放射図およ

び超音波検査所見を比較検討した。その結果、TR の残存は術後肺動脈楔入圧高値例、僧帽弁切開不充份例にみられたが、肺血管抵抗は有意に関係しなかった。しかし、機能的 TR の予後は、術前、術中所見では予見出来ない事が多く、積極的に TAP を行うべきと考える。